REMARKS

The rejection of claims 1 - 17 under 35 USC 103 over the various references is respectfully traversed

Claims 1,2

Applicants readily agree with the holding of the cited case, Titanium Metals. Applicants maintain, however, that this case is not relevant (or the presumption has been overcome) because one skilled in the art would not have expected that the failure temperature would be over 730 degrees C for the parameters required by the claims.

It is well known that an unanticipated beneficial feature in a limited range of a parameter may be patentable even if the range of the relevant parameter has been disclosed; if one skilled in the art would not have expected the beneficial feature. Applicants call the examiner's attention to Fig. 4 of the present application, which summarizes the prior art. The failure temperature for a barrier thickness of less than 0.75nm is less than 500

degrees C, which is not acceptable. Similarly, the failure temperature for a barrier thickness of less than 2nm is less than 650 degrees C, which is also not acceptable. Therefore, one skilled in the art would not have thought to use a barrier of such a low thickness.

Claim 1, as amended, covers both the case when the barrier layer remains on the bottom of the via and the case when the barrier layer is removed from the bottom.

Support for the limitation that the failure temperature is greater than 730 degrees Centigrade is provided by Fig. 8 and the accompanying discussion.

Support for the limitation that x in TaN_x is between 1.2 and 1.5 is provided by Fig. 5 and the accompanying discussion.

Support for the limitation that the thickness of the barrier layer is less than 4nm is provided by Fig. 4 and the accompanying discussion.

Applicants note that the Nogami reference (Applicants' prior art) teaches that the Nitrogen in the TaN compound has an atomic percentage of 67% for TaN_2 and a range of 85 - 90at.% for 30-40 at. Weight percent a mixture, while Applicants' material has Nitrogen in an atomic percentage of 55 to 60at.%. The equivalent atomic weight percentages are 30 - 40at.wt.% for Nogami and 9 - 10 at.wt% for the present invention.

Claim 3

Claim 3 is dependent on claim 1 and therefore also patentable.

Applicants point out that Applicants' Prior Art does not show all the limitations of claim 3 except for the thickness.

Applicants call the examiner's attention to paragraph 101 of Werkhoven, showing that the composition of the liner layer is graded; i.e. not uniform, as called for by claim 1.

Applicants agree that paragraph 103 of Werkhoven specifies that the barrier region may be in a range of 2nm to 20nm, but point out that the cited paragraph refers to WN, not to TaN. The numbers for thickness therefore are not relevant unless the examiner can find a reference showing that WN and TaN are equivalent with respect to the parameters claimed.

Further, Applicants point out that Werkhoven specifies two barrier layers, so that the net thickness will be the sum of the two layers. Claim 3 has been amended to specify that there is only one barrier layer.

Yet further, Applicants point out that paragraph 103 of Werkhoven shows a first range of 2nm to 20nm, which overlaps Applicants' range, but that the preferred value is 5nm. There is no indication in Werkhoven that a film thickness of 2nm would have the chemical composition specified by claim 1 or the failure temperature specified in claim 1.

In addition, the transition region 434 in Werkhoven is in the range 1nm to 8nm, with a preferred value of 1nm, so that the preferred thickness of WN

is 6nm. Also, the transition region is graded, having a Cu proportion of 50% at the interface with the conductor.

Applicants note that Werkhoven does not specify any value for x for a layer of TaN_x.

Applicants maintain, therefore, that the combination of Werkhoven and Nogami is not comparable to the claims, since it does not show: a) that WN is equivalent to TaN; b) that the failure temperature is within the claimed range; or c) that the value of x is in the claimed range.

In particular, Fig. 4 of the presentspecification shows that a structure fabricated according to the prior art, e.g. Werkhoven and Nogami, having a thickness of less than 4nm, would have an unacceptable failure temperature.

Therefore, the Examiner's combination does not suggest the current claims.

Claims 4 - 10

The only claims remaining in this range are claims 6 and 7.

Applicants disagree with the examiner's interpretation of the Chen reference expressed in the second full paragraph of page 4, lines 4 - 11 of the paragraph. Applicants agree that some dielectrics are mechanically weak (e.g. the low K dielectrics). Applicants point out, however, that mechanical strength increases with thickness, so that it makes no sense to argue that the liner thickness should be decreased to the smallest value in the range to provide support for the dielectric. Support, if any, would be provided by a thickness in the high end of the range disclosed, not the low end. Further, the area of an IC covered by the vias is a very small fraction of the total, so that one skilled in the art would not be led to change the thickness of the barrier layer, because that would provide negligible support to the dielectric layer.

The Chen reference does not specify a particular thickness value for a sufficiently strong liner, so that the examiner does not have support for her assertion that a thickness of 0.5nm would provide sufficient support for a weak dielectric.

With respect to resistivity, the examiner seems to have confused resistivity with resistance. Resistivity is characteristic of the bulk material and its temperature. Resistance depends on the dimensions. Resistance = (Resistivity*length)/area (Handbook of Chemistry and Physics, 41st edition, page 3119). The examiner therefore has no support for her assertion that a particular thickness of liner will provide the specified resistivity. The cited paragraph 46 of the present specification describes the variation of the failure temperature as a function of thickness, not the resistivity.

The cited paragraph, in fact, shows that the prior art teaches away from the present invention in that the prior art in Fig. 4 teaches that an acceptable failure temperature is not reached until the thickness is greater than 4nm. Thus, the cited paragraph establishes that the prior art taught that a barrier liner with a thickness less than 4nm does not have an acceptable failure temperature of 730 degrees C.

Applicants note that when the barrier material remains on the bottom of the via, it is part of the resistance of the interconnect path, so that one skilled in the art would realize that a high resistivity is detrimental. One skilled in the

art would not be led to use a high-resistivity barrier material by the cited references in any combination because the prior art taught that a thickness of less than 4nm had an unacceptable low failure temperature.

Applicants note that none of the references show the failure temperature for their method of manufacture or composition of material. Therefore, since the references do not show or suggest the composition of the material according to the present invention, use of these references is not valid.

Claims 11 - 12

Claim 11 has been amended also. Claim 11 requires that the (upper) interconnect be connected directly, i.e. with no liner on the bottom of the via, to a lower circuit element (including a lower interconnect).

The remarks on claim 1 apply here also.

Claim 12

Claim 12 adds to claim 11 the limitation that the value of x is within a specified range.

Applicants note that the Nogami reference (Applicants' prior art) teaches that the Nitrogen in the TaN compound has an atomic percentage of 67% for TaN_2 and a range of 85 - 90at.% for a 30-40 at. Weight percent mixture, while Applicants' material has Nitrogen in an atomic percentage of 55% to 60%. The equivalent atomic weight percentages are 30 - 40at.wt.% for Nogami and 9 – 10 at.wt% for the present invention. Thus, the value of x in TaN_x is 2 for TaN_2 and about 9 for the mixture, all of which are outside the claimed range.

Applicants note that Werkhoven does not specify any value for x for a layer of TaN_x.

Thus, the references cited by the examiner do not teach anything about the claimed range atd do not render claim 12 unpatentable..

Claim 13

Applicants point out that Applicants' Prior Art does not show all the limitations of claim 13 except for the thickness.

Applicants call the examiner's attention to paragraph 101 of Werkhoven, showing that the composition of the liner layer is graded; i.e. not uniform, as called for by claim 11.

Applicants agree that paragraph 103 of Werkhoven specifies that the barrier region may be in a range of 2nm to 20nm, but point out that the cited paragraph refers to WN, not to TaN. The numbers for thickness therefore are not relevant unless the examiner can find a reference showing that WN and TaN are equivalent with respect to the parameters claimed.

Further, Applicants point out that Werkhoven specifies two barrier layers, so that the net thickness will be the sum of the two layers. Claim 3 has been amended to specify that there is only one barrier layer.

Yet further, Applicants point out that paragraph 103 of Werkhoven shows a first range of 2nm to 20nm, which overlaps Applicants' range, but that the preferred value is 5nm. There is no indication in Werkhoven that a film thickness of 2nm would have the chemical composition specified by claim 11 or the failure temperature specified in claim 11.

In addition, the transition region 434 is in the range 1nm to 8nm, with a preferred value of 1nm, so that the preferred thickness of WN is 6nm. Also, the transition region is graded, having a Cu proportion of 50% at the interface with the conductor.

Applicants note that Werkhoven does not specify any value for x for a layer of TaN_x.

Applicants maintain, therefore, that the Werkhoven example is not comparable to the claims, since it does not show that: a) WN is equivalent to TaN; b) the failure temperature is within the claimed range; or c) that the value of x is in the claimed range.

Claims 14 - 17 have been canceled.

Summary

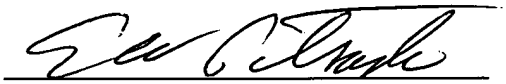
In summary, the curve in Fig. 4 shows that one skilled in the art and having the knowledge of the prior art would not be led to form a barrier layer according to claim 1 or claim 11 because Fig. 4 teaches that a barrier layer will have an acceptable failure temperature only with a thickness of greater than 4nm.

In contrast, the data in Fig. 8 show that a barrier layer having a composition according to the present invention unexpectedly has an acceptable failure temperature down to a thickness of less than 0.5 nm.

Therefore, the references cited by the Examiner. In any combination, do not render any of the present claims obvious because they do not teach or suggest the parameters of the present claims.

For the foregoing reasons, allowance of the claims is respectfully solicited.

Respectfully submitted,



by: Eric W. Petraske, Attorney
Registration No. 28,459
Tel. (203) 798-1857